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The overall classification of this briefing is
UNCLASSIFIED

NDIA Hard Problems Workshop - Cyber COI Deep Dive

5 Nov 14

Dr. Richard Linderman

Cyber COI Steering Group Lead

Outline

- BLUF
- **Cyber COI Overview**
- Roadmap Development Process
- Cyber COI "4 + 2" S&T Roadmaps and Recent Successes
- Hard Problems and Gaps
- Engagements, Way Ahead, and Opportunities
- Summary

BLUF – Bottom Line Up Front

- Established, mature, and coordinated community
- Cyber S&T aligned to expanding operational capability gaps/priorities
- Cyber S&T contributions to nearly all Seven DoD Hard Problems
- Driving deeper engagement with industry and international partners

S&T Influencing the DoD Cyber Landscape

"...we will continue to invest in capabilities critical to future success, including... operating in anti-access environments; and prevailing in all domains, including cyber."

- President Obama, January 2012

Cyber Investment Management Board (CIMB)

COCOMs

Department of Defense Strategy for Operating in Cyberspace

CYBERSPACE POLICY REVIEW

TRUSTWORTHY CYBERSPACE: STRATEGIC PLAN FOR THE FEDERAL CYBERSECURITY RESEARCH AND DEVELOPMENT PROGRAM

S&T Community of Interest

Enhance United States National Security & Economic Prosperity

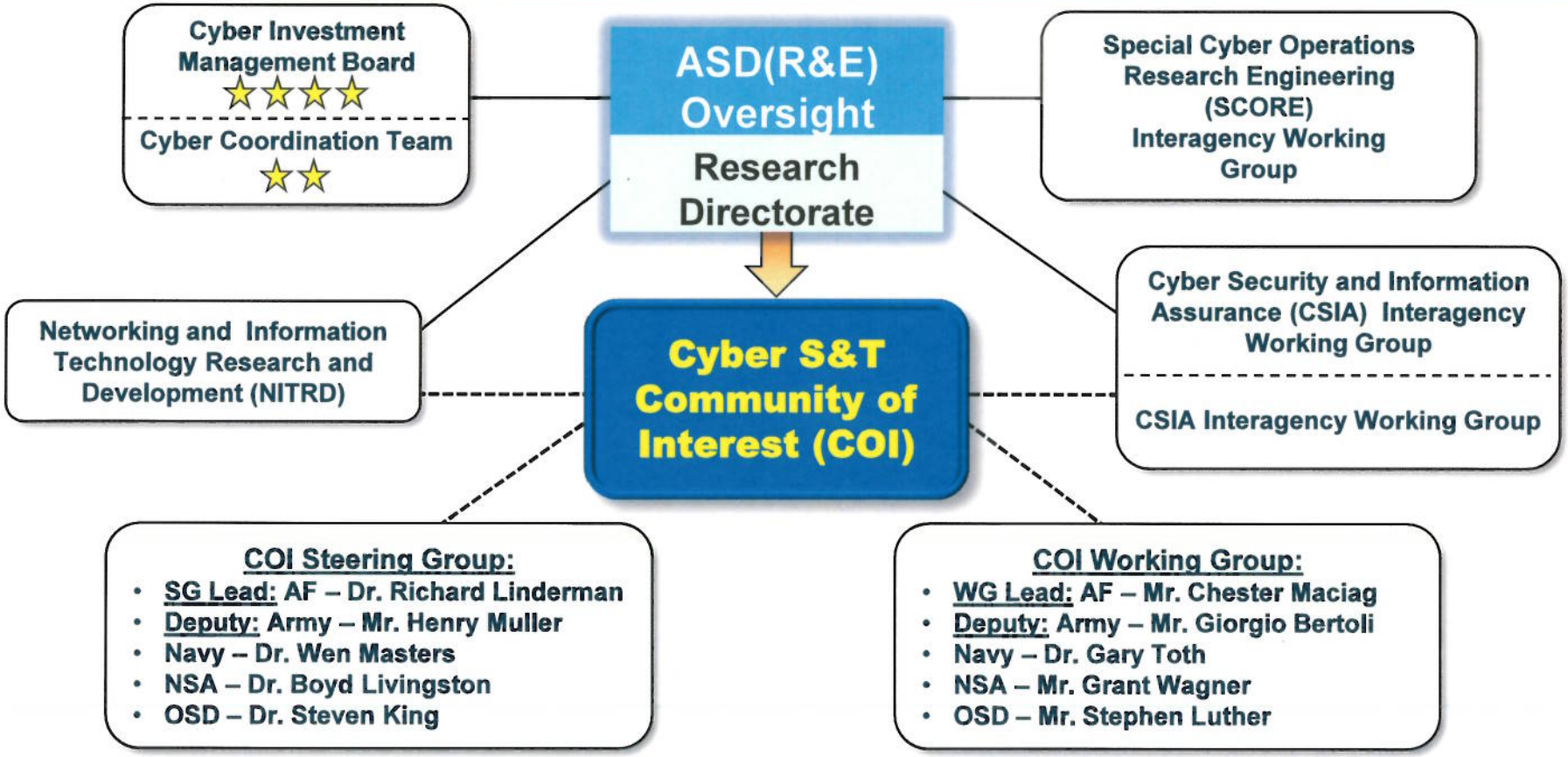
Defend the Homeland

Build Security Globally

Project Power and Win Decisively

Mission Assurance
Agility
Resiliency
Foundations of Trust

DoD Cyber S&T Coordination



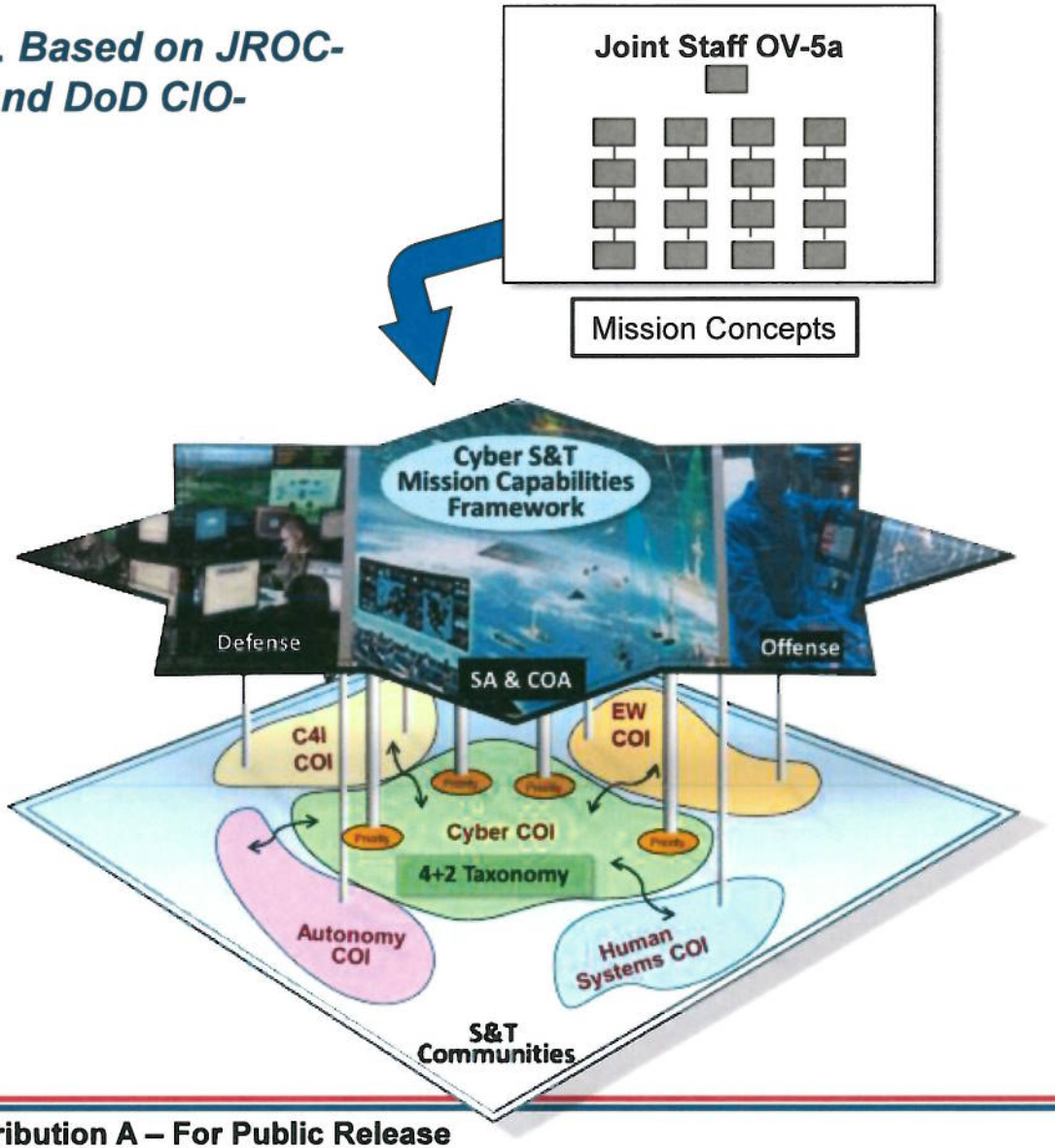
Users			Research Community						Users	
DISA	NSA IAD	DCIO	ONR/ NRL	AFRL/ AFOSR	NSA Research	DARPA	RDECOM	DTRA	USSTRATCOM/ USCYBERCOM	USD(I)

Community of Interest and Working Groups are the primary means for oversight, collaboration, & coordination

Cyber COI - Scope

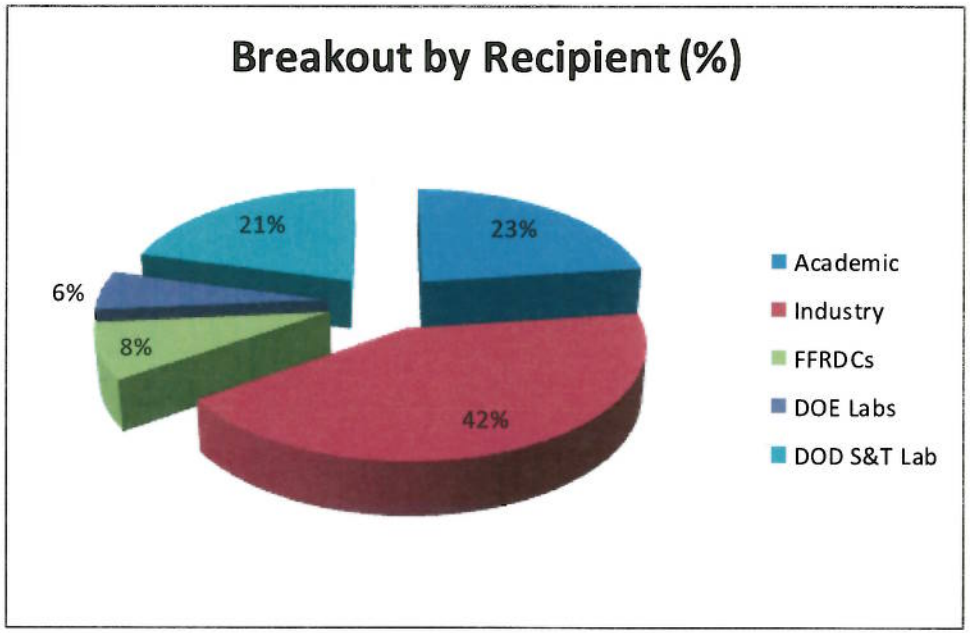
An Operational Domain: JS OV-5a. ***Based on JROC-Approved Capability Documents and DoD CIO-developed Architectures***

- Spans Defense, Effects, Situational Awareness-Course of Action
- Includes enterprise, tactical and embedded
- Cuts across all domains
- Touches C4I, EW, Autonomy, and Human Systems COIs
- Transcends S&T across all DOTMLPF
- QDR Tenets Addressed
  - Mitigates Threats
  - Delivers Affordable Capability
  - Affords Technological Surprise



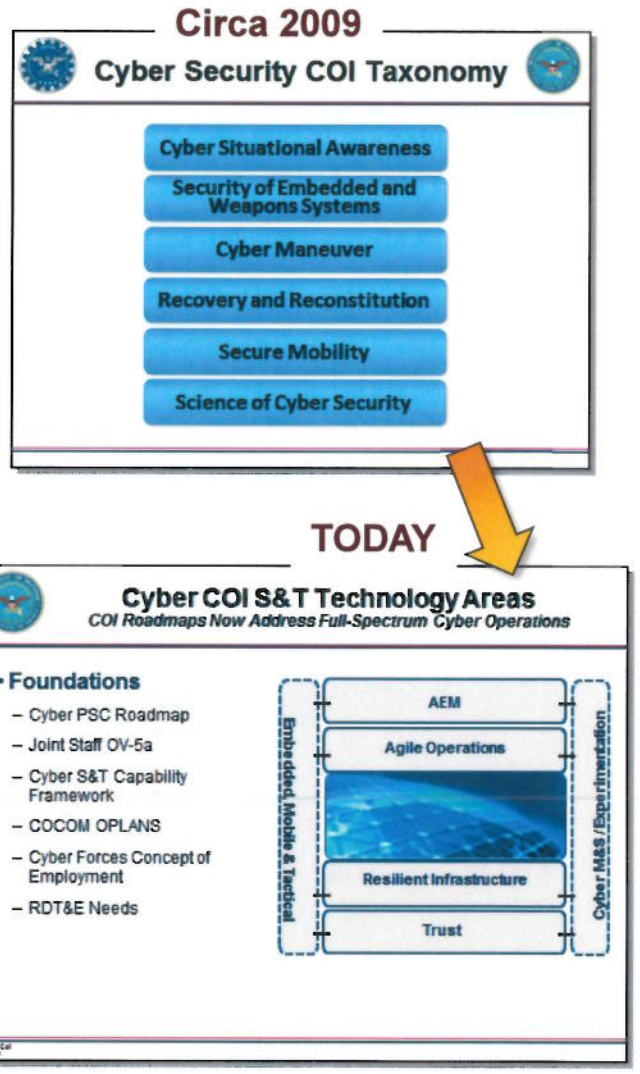
DoD Cyber S&T: Performers
(FY14 Execution)

- **Service S&T Labs**
  - AFRL, RDECOM, NRL, SPAWAR
- **DoD Agencies**
- **DoE Labs**
- **FFRDCs**
- **Industry**
- **Academia**



Cyber COI Recent Activities

- **(U) Briefed roadmap to S&T EXCOM in May**
  - (U) Cyber PSC → Cyber [Security] COI
  - (U) Incorporated findings of Cyber Investment Management Board
  - (U) High-level cyber S&T metrics
- **Evolving toward a Level 4 COI**
  - (U) International: Working multilateral cyber S&T agreements
  - (U) Academic: HBCU-MI Cyber Center of Excellence
  - (U) Industry: Engagement and collaboration leading to strategic Reliance



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Cyber S&T Roadmap Evolution

CIMB Driven Developments

Technology Challenges

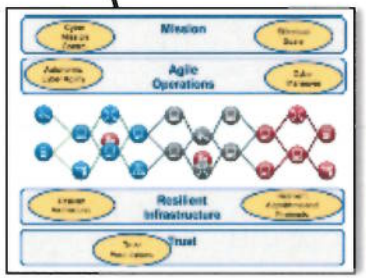
Cyber S&T Capability Framework

Way Ahead: CIMB & Cyber Metrics Maturation

2009 | 2010 | 2011 | 2012 | 2013 | 2014

COI | PSC | COI

GOF Study 4.18 DoD S&T Investment in Cyberspace Security and Information Assurance



Cyber Forces Concept of Employment

Roadmap Development and Priority Gaps

Cyber S&T Capability Framework

From CIMB Analysis of JS OV-5

Defense

- Reduce attack surface and increase resiliency of DODIN
- Reduce attack surface and increase resiliency of embedded/weapons systems
- Discover, understand, and engage threats

Engagement

- Active defense
- Respond to large-scale threats

Situational Awareness and Courses of Action

- Cyberspace situational awareness
- Understand cyber dependencies of missions
- Integrated course of action, cyber and non-cyber

Cyber S&T Capability Framework
Examples of High Level Metrics

Defense

- Increase total resources required by an adversary to achieve an effect
- Reduce adversary dwell time
- Reduce time until defense forces are aware of adversary

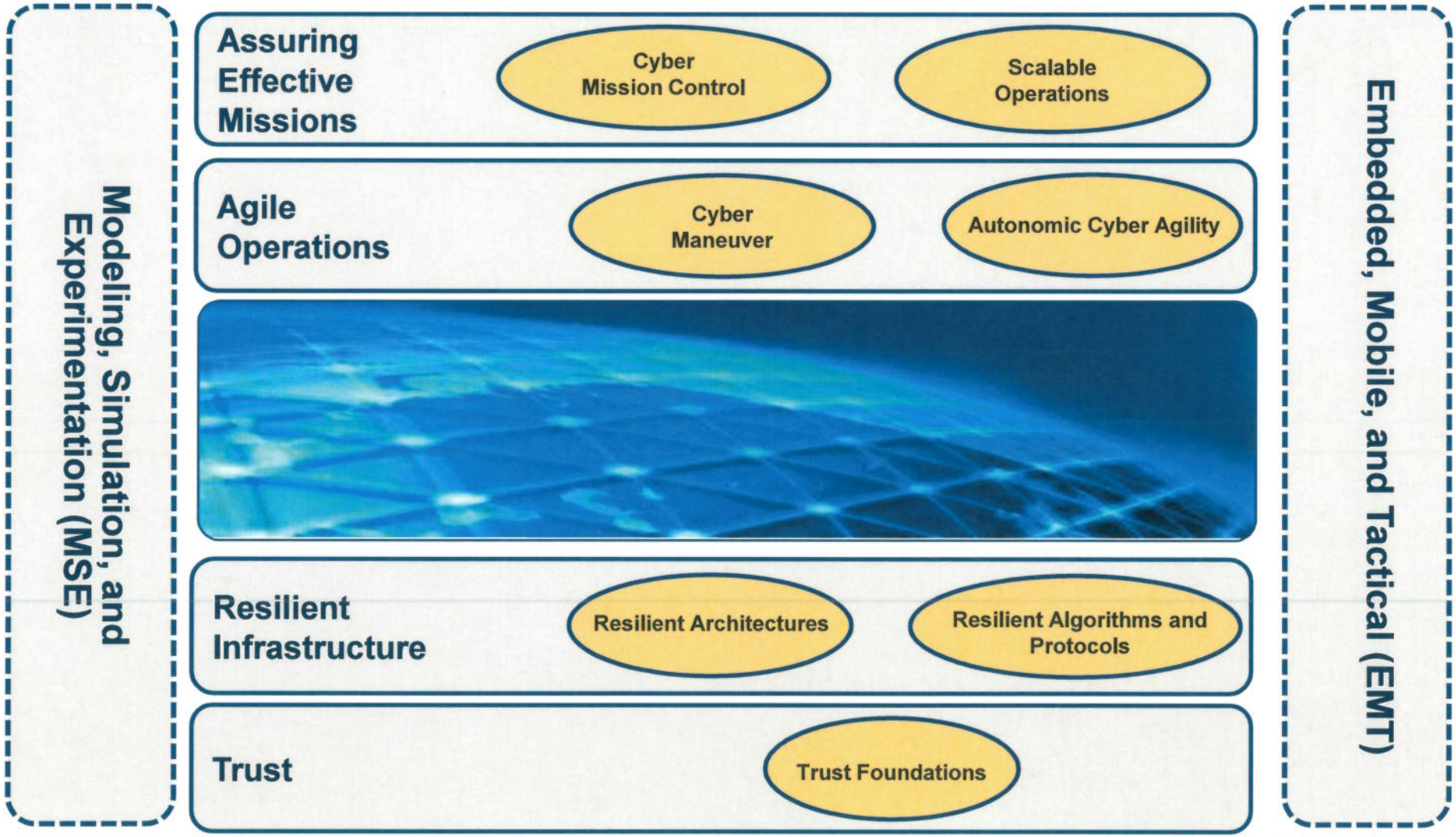
Engagement

- Increase cyber readiness
- Increase sophistication of campaign plans

Situational Awareness and Courses of Action

- Reduce time to map mission dependencies on cyber assets
- Improve robustness of mission-to-cyber mapping
- Increase quality of generated COA's

Cyber S&T Roadmap
Technology Challenges & Cross Cutting Areas



DoD's Joint Cyber S&T Focus Areas

Assuring Effective Missions	Assess & control the cyber situation in mission context
Agile Operations	Escape harm by dynamically reshaping cyber systems as conditions/goals change
Resilient Infrastructure	Withstand cyber attacks, while sustaining or recovering critical functions
Trust	Establish known degree of assurance that devices, networks, and cyber-dependent functions perform as expected, despite attack or error
Embedded, Mobile, & Tactical (EMT)	Increase the capability of cyber systems that rely on technologies beyond wired networking and standard computing platforms
Modeling, Simulation, & Experimentation (MSE)	Simulate the cyber environment in which the DoD operates to enable mission rehearsal and a more robust assessment and validation of cyber technology development

CROSS CUTTING

Outline

- BLUF
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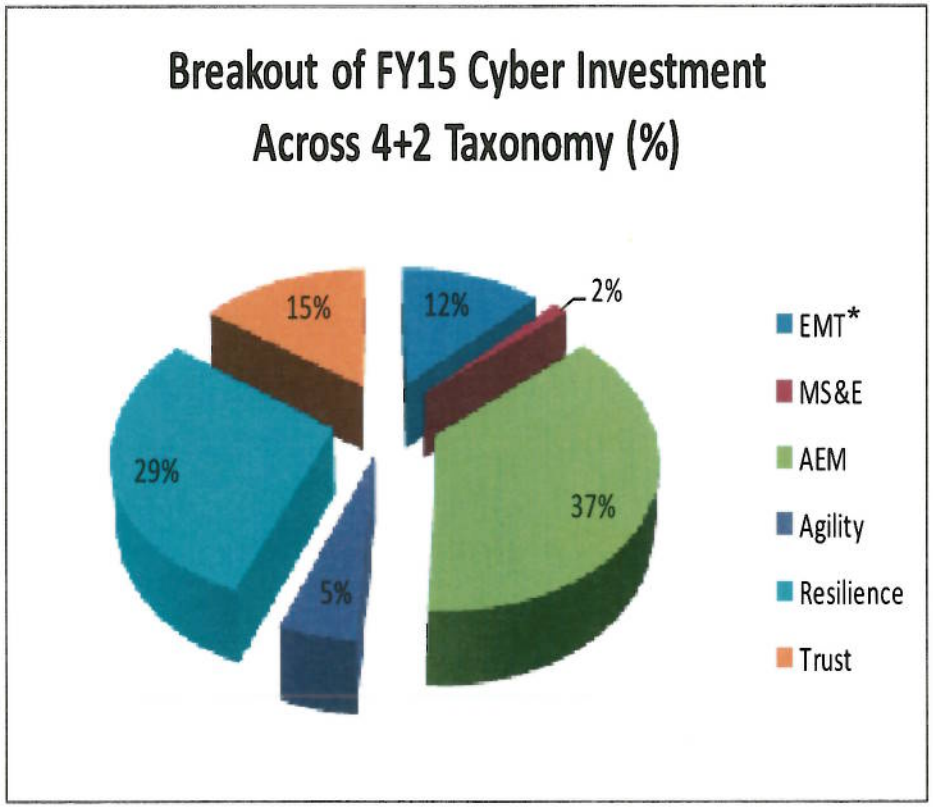
Cyber FY15 S&T Across 4+2 Technology Areas

- **Funding Observations**
  - Appropriately increasing emphasis in AEM and EMT
  - Continued strong demand for Resilience
  - Trust focuses on military-unique topics
  - Agility operational goals and tradeoffs under discussion
  - Under-investment in MS&E resulting in acquisition and operational gaps

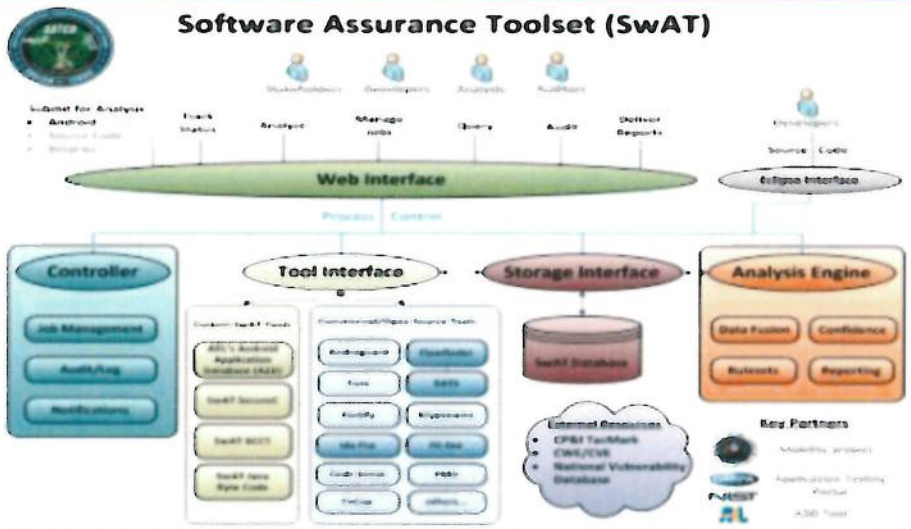


**Note: The EMT figures include some overlap with the other technology areas.*

Trust Foundations
Objectives / Accomplishments / Challenges

Objectives:

- **Trusted Components and Architectures**: Develop measures of trustworthiness for cyber components and large systems of varying pedigree and trustworthiness
- **Scalable Supply Chain Analysis and Reverse Engineering**: Analyze, attribute, and repurpose hardware and software at the speed and scale required for real-time strategic engagement



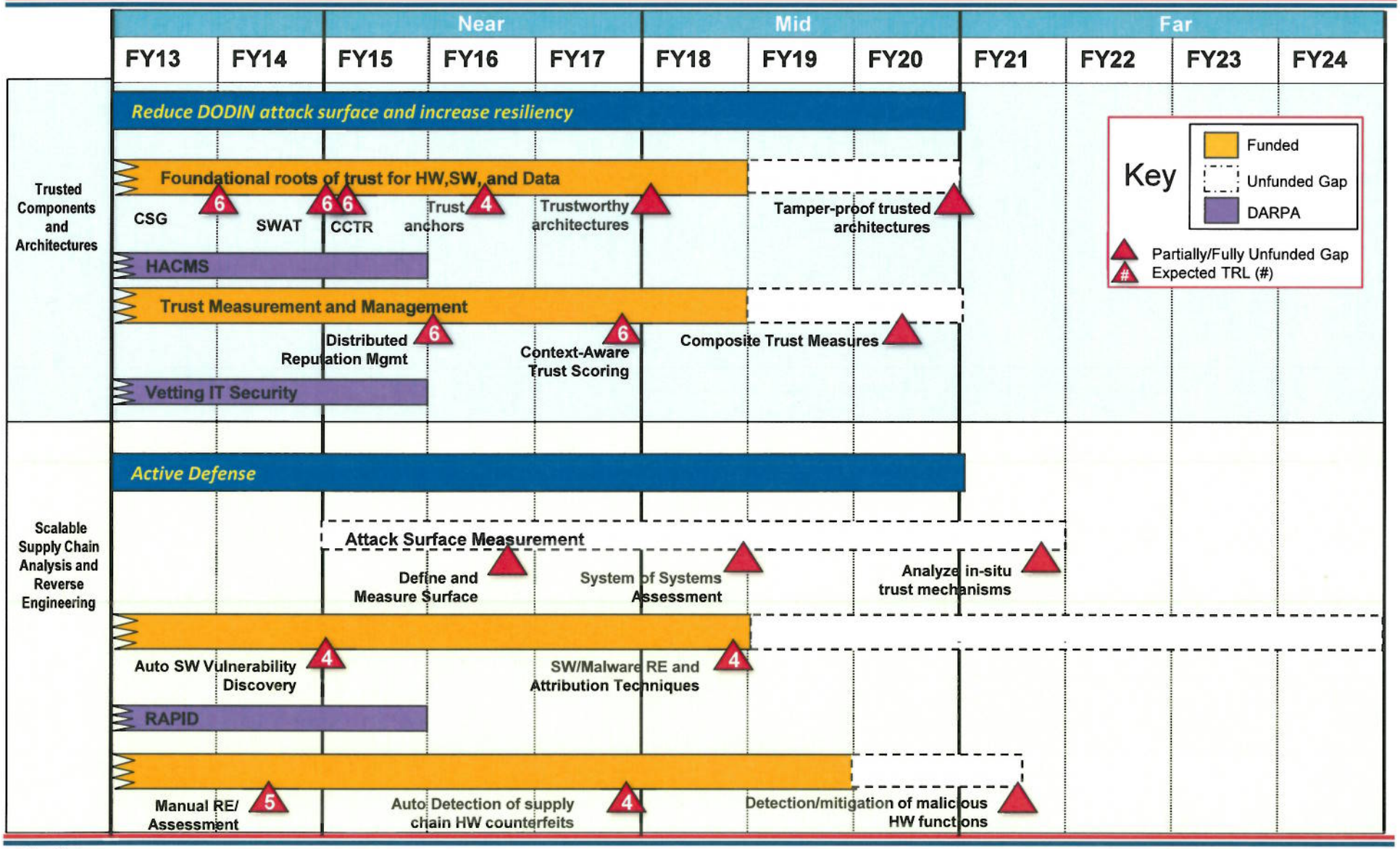
Accomplishments:

- FY13/14 Success Stories
  - Army: SW Assurance Toolkit (SWAT)
  - AF: Secure Processor
  - AF: Context/Content Aware Trusted Router
  - AF: Secure View

Technical Challenges:

- Development of Trust Anchors for component-level and composed HW and SW
- Tamper-proof/evident HW and SW components and systems
- Contextual threat/trust scoring calculus
- Rapid, assisted, and automated HW and SW analysis and validation
- Algorithms for accurate attribution of malware authors and supply chain tampering

Trust Foundations Roadmap

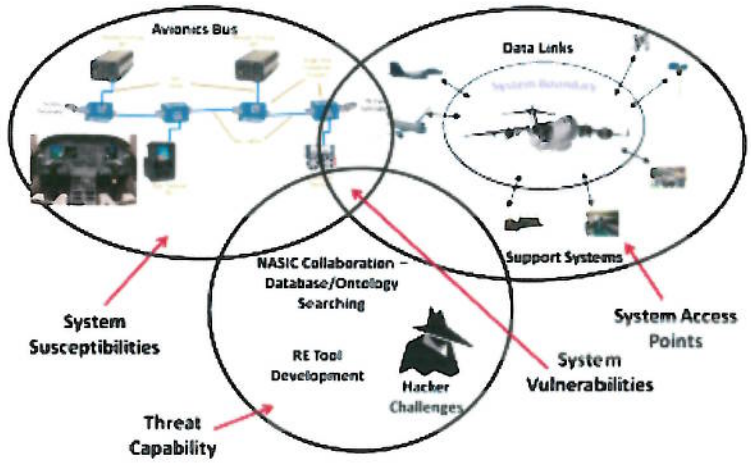


Resilient Infrastructure

Objectives / Accomplishments / Challenges

Objectives:

- **Resilient Architectures:** Develop integrated architectures that are optimized for the ability to absorb shock and speed recovery to a known secure operable state.
- **Resilient Algorithms and Protocols:** Develop novel protocols and algorithms to increase the repertoire of resiliency mechanisms available to the architecture that are orthogonal to cyber threats.



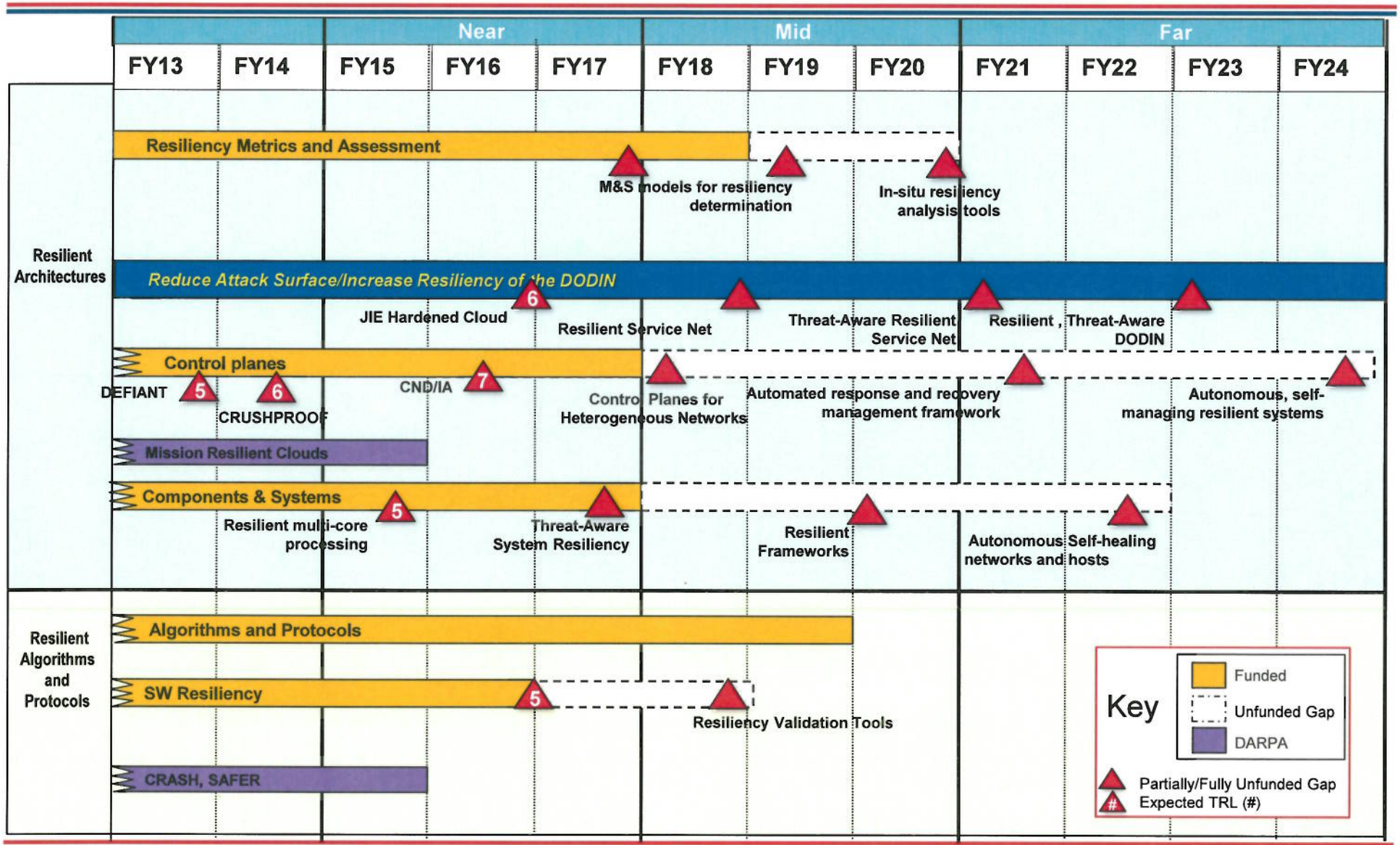
Accomplishments:

- FY13/14
  - Army DEFIANT
  - Army: CRUSHPROOF

Technical Challenges:

- Assessment environments and tools for measuring resiliency of HW, SW, networks, and systems
- Calculus for relating resiliency concepts into measurable operational impact and automated DODIN defense actions
- Resilient overlay control planes that orchestrate defense of heterogeneous DODIN systems
- Secure, LPI/J, energy-efficient, mobile communication protocols
- Certifiable, agile, and affordable mobile device HW, OS, and app ecosystem

Resilient Infrastructure Roadmap

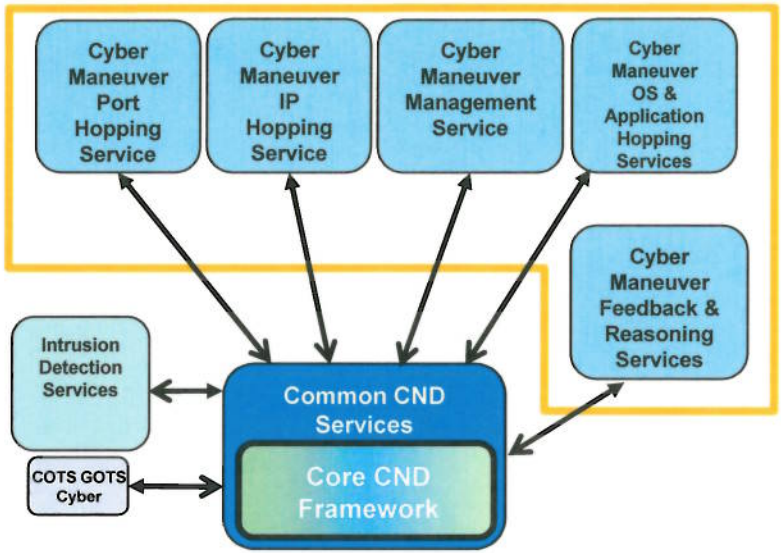


Agile Operations

Objectives / Accomplishments / Challenges

Objectives:

- **Cyber Maneuver:** Develop mechanisms that enable dynamically changing cyber assets to be marshaled and directed toward an objective – to create or maintain a defensive or offensive advantage
- **Autonomic Cyber Agility:** Speed the ability to reconfigure, heal, optimize, and protect cyber mechanisms via automated sensing and control processes



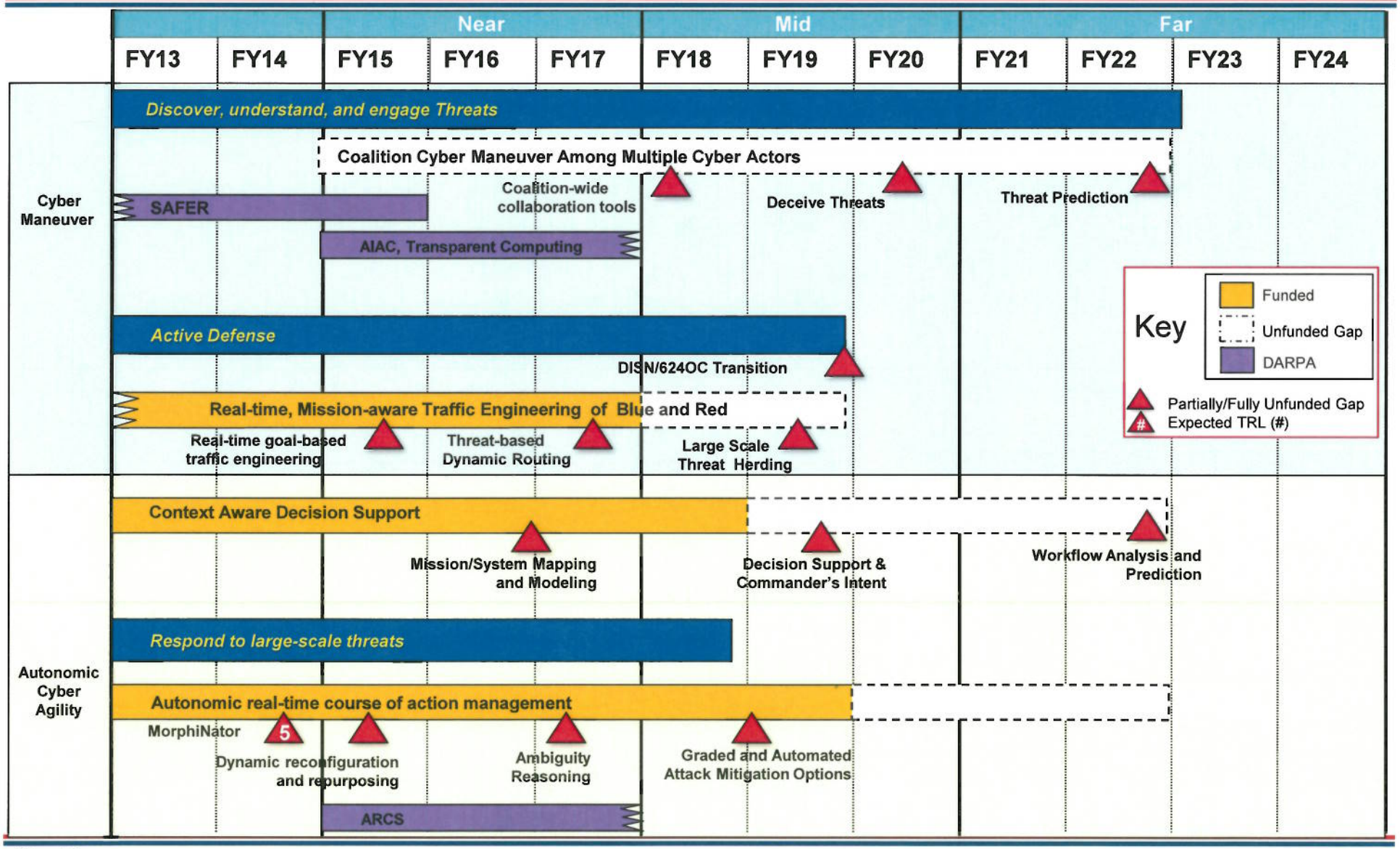
Accomplishments:

- Army: MorphiNator
- AF: ARCSYNE/COSYNE

Technical Challenges:

- Real-time, mission-aware traffic engineering including routing of threats
- Collaborative, coordinated cyber maneuver of multiple actors and forces (including coalition)
- Cyber maneuver for deceiving threats
- Dynamic reconfiguration of networks, systems and applications
- Autonomous reconfiguration

Agile Operations Roadmap



Assuring Effective Missions
Objectives / Accomplishments / Challenges

Objectives:

- **Cyber Mission Control:** Develop tools and techniques that enable efficient models of cyber operational behaviors (cyber and kinetic) to determine the correct course of action in the cyber domain
- **Scalable Operations:** Develop ability to operate and survive during operations conducted by large-scale threats

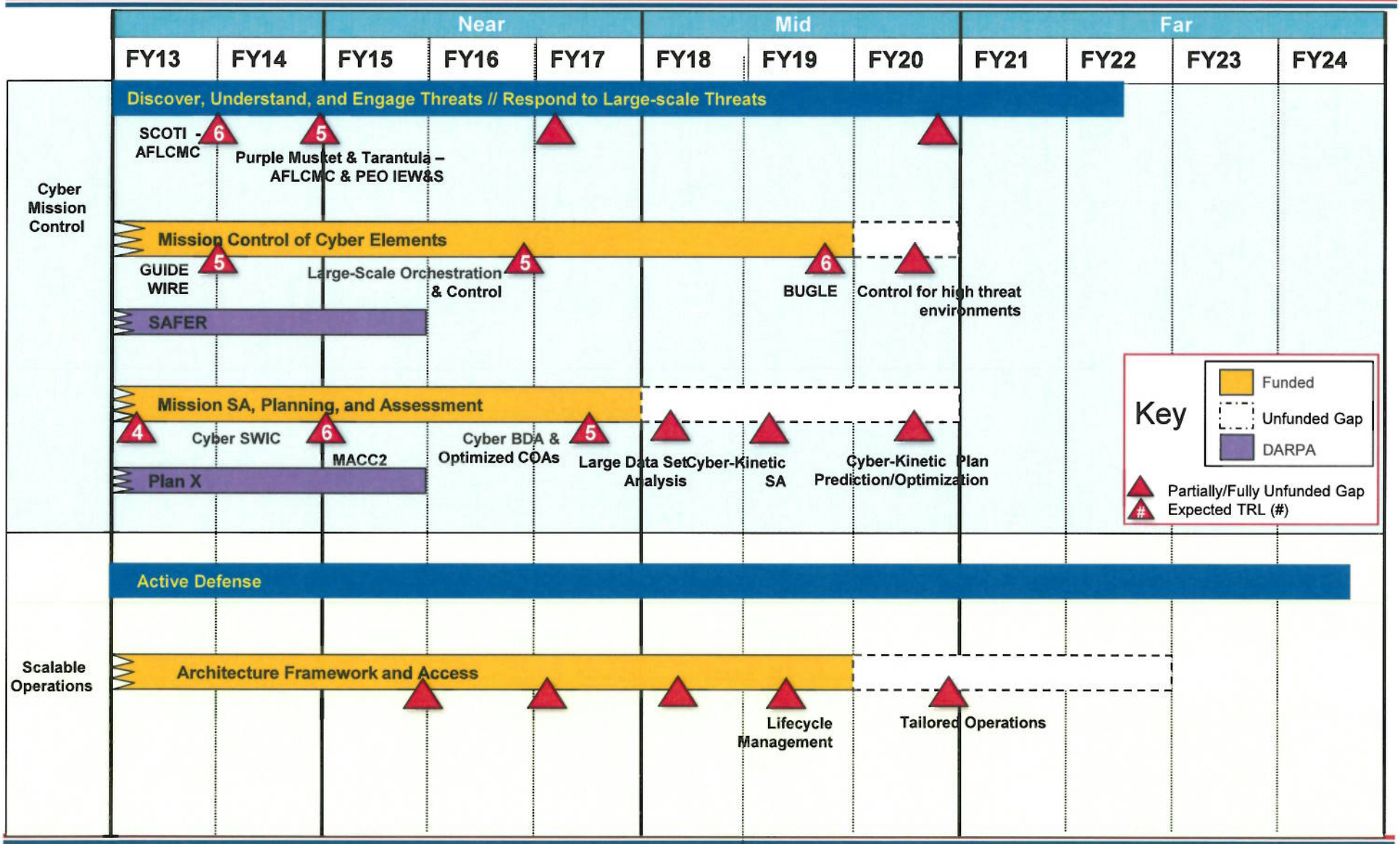
Accomplishments:

- Promised last year for FY13
  - OSD: Purple Musket
  - Navy: Flying Squirrel BT Integration
- FY13/14 AF: Mission Aware Cyber C2 (MACC2)

Technical Challenges:

- Tools for mapping and real-time analysis of missions to enable cyber/kinetic situational awareness
- Understanding dynamically evolving missions and their dependencies, identifying cyber/kinetic change indicators, updating models and resolving cross-dependencies, projecting change trends
- Decision Support and reasoning tools that factor in multiple dimensions (e.g., attribution, severity, reversibility of effect, BDA, …)

Assuring Effective Missions Roadmap

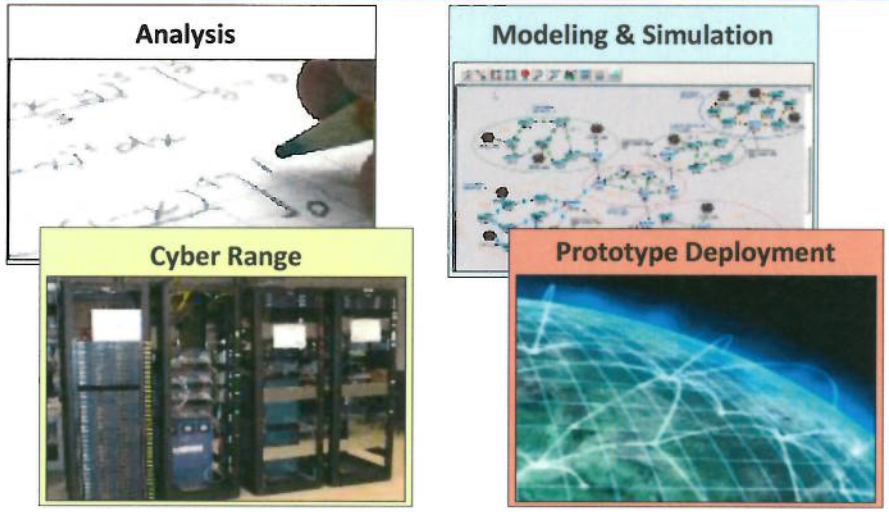


Modeling, Simulation, & Experimentation

Objectives / Accomplishments / Challenges

Objectives:

- **Simulation and Experimentation Technology**:
  - Enable robust, quantifiable, and repeatable assessment and validation of candidate cyber technology
- **Models & Analysis:**
  - Simulate the cyber operational environment with high fidelity
  - Describe and predict interactions and effect between physical and cyber domains



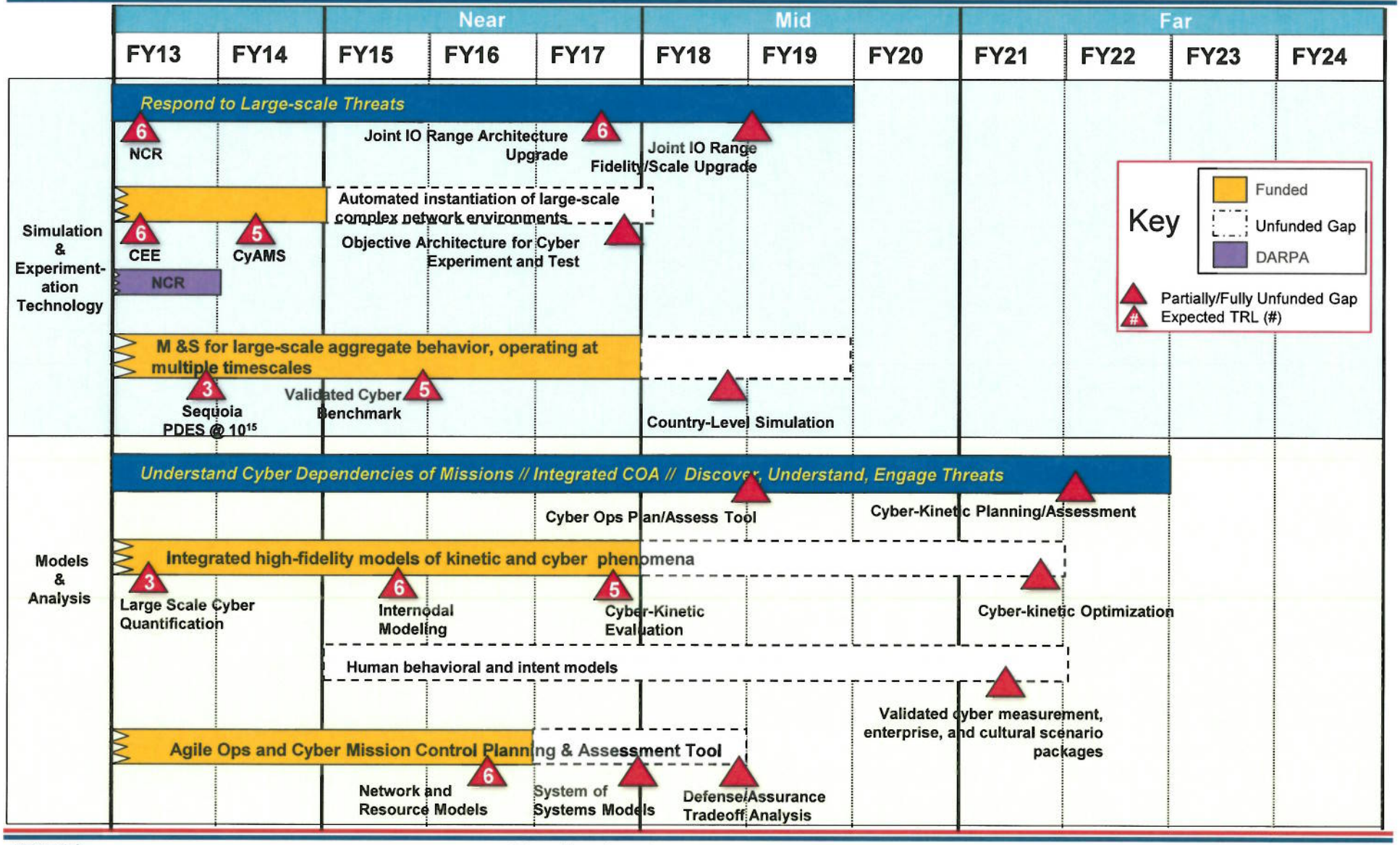
Accomplishments:

- Sequoia HPC achieved world record 10^{15} events/sec
- Army: Cyber Army Modeling & Simulation (CyAMS)
- AF: Cyber Experimentation Environment

Technical Challenges:

- Automated, rapid instantiation of large-scale, complex computing and network environments
- Objective architecture for heterogeneous range component integration and synchronization
- M&S for large-scale aggregate Internet behavior, operating at multiple timescales
- Integrated high-fidelity models of kinetic and cyber phenomena
- Human behavioral and intention models
- Planning and Assessment algorithms to evaluate operational agility and assurance

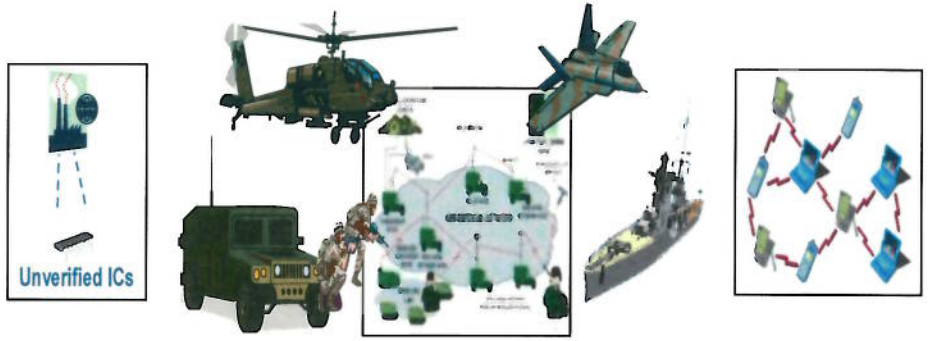
Modeling, Simulation, and Experimentation (MSE) Roadmap



Embedded, Mobile, and Tactical
Objectives / Accomplishments / Challenges

Objectives:

- **Mobile and Tactical Systems Security**
  - Secure information sharing at tactical edge
  - Reduction of mobile computing attack surface in all its aspects
- **Embedded Tactical Composite Trust**
  - Architectural approaches for composing embedded systems
  - Security capabilities needed for robust and secure composed systems
- **Leverage International Partners**



Apply the Cyber S&T Roadmap to Embedded, Mobile, and Tactical Environments

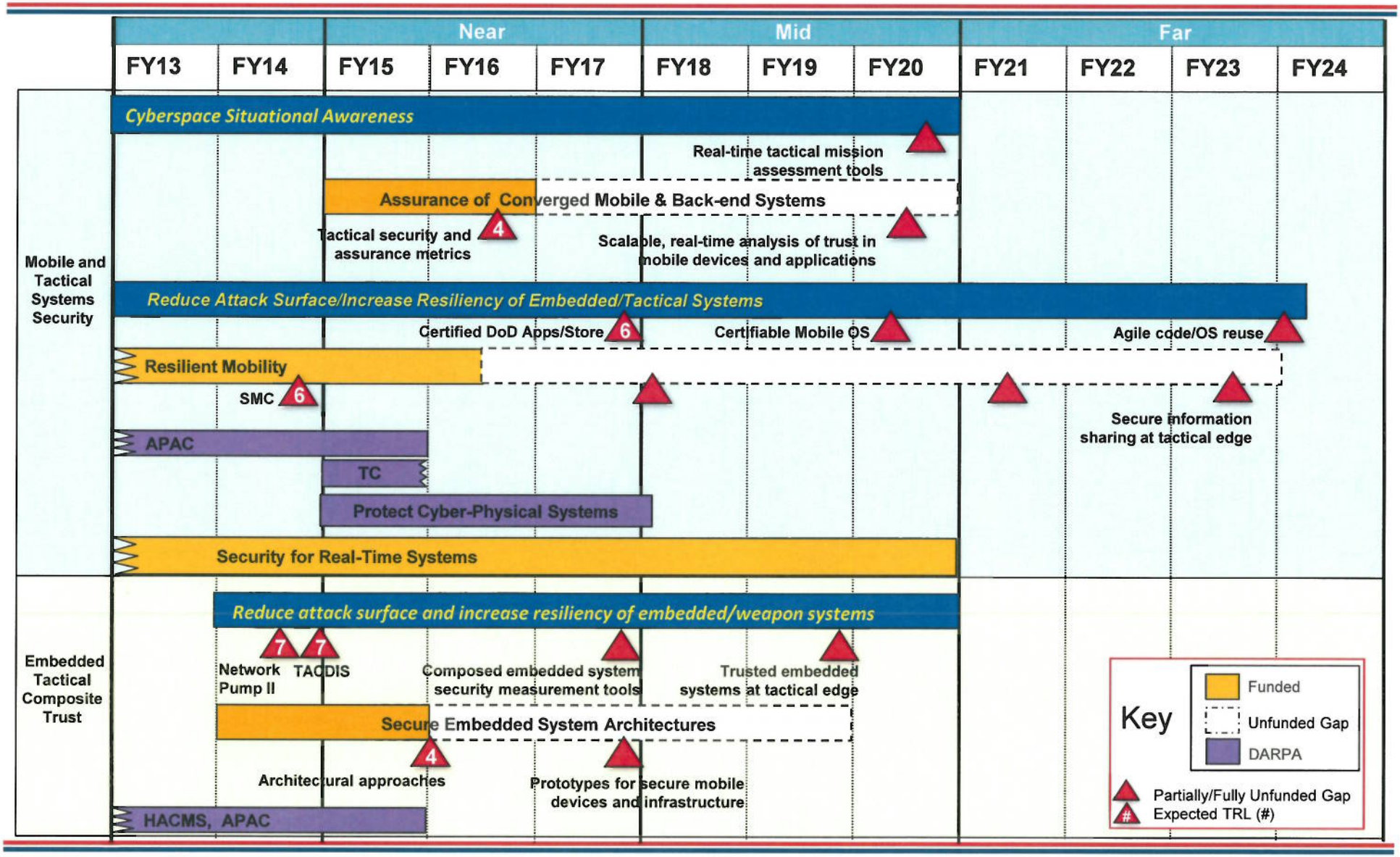
Accomplishments:

- Navy: Network Pump – II
- Army: Tactical Army Cross Domain Information Sharing (TACDIS)

Technical Challenges:

- Secure, LPI/J, energy-efficient, mobile communication protocols
- Certifiable, agile, and affordable mobile device hardware, OS, and app ecosystem
- Tools to monitor and assess assurance of cyber operations in converged strategic/tactical systems
- Self-monitoring systems in systems, including real-time integrity measurement
- Tools to monitor and assess the health and behaviors of embedded cyber systems - security of weapons systems and platforms

Embedded, Mobile and Tactical Roadmap



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Specific Gap Assessment

Defense

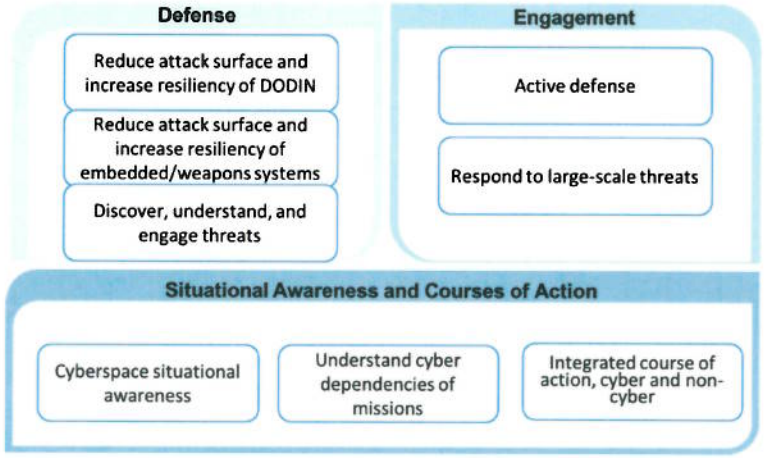
- Trustworthy embedded system architectures composed of components of mixed trust
- Trust scoring mechanisms
- Scalable HW/SW analysis and verification techniques
- Resilient mobility

Engagement

- Control planes for heterogeneous components and systems
- Threat-aware defenses
- Real-time defensive traffic management

Situational Awareness and Courses of Action

- Graded options responsive to commander's intent
- Analysis of Mission Dependencies to Cyber Infrastructure
- Cyber-Kinetic integration, planning, and assessment



Measurement and Metrics

- Quantifiable attack surface measurement
- Component and system resiliency metrics
- Threat-based agility metrics
- Calculus for Mission Assurance
- Cyber modeling and simulation and experimentation

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Community Engagement

- **TTCP Cyber Grand Challenge (Kickoff Jun 2014)**
  - Trust Foundations
  - Mission Assurance Through Mission Awareness (MASA)
  - Integrated Cyber-EW Operations
- **STRATCOM/J8 EW-Cyber ICD (Draft Dec 2014)**
- **Five RDA-TFs for Cyber**
- **DoD Innovation Marketplace**
  - Bi-Weekly engagement
  - AFRL IR&D Review

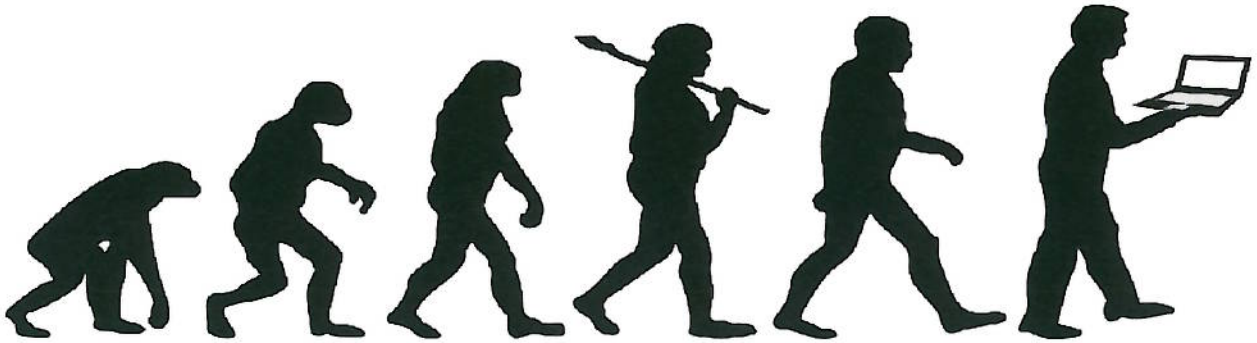
Terms:
ICD: Initial Capabilities Document
RDA-TF: Research, Development, & Acquisition Task Force
TTCP: The Technical Cooperation Panel

DoD Unique Cyber Capabilities

- **Experimentation/Assessment**
  - Cyber Experimentation Environment (CEE)
  - Army Cyber Research & Analytics Laboratory (ACAL)
  - D-Shell
  - High Performance Computing (HPC)
  - CND data sets
- **Telecommunications/Wireless**
  - Telecommunications Labs (CERDEC)
  - Communications System Integration Laboratory (CSIL)
  - HI-FI Advance Waveform and Cyber laboratory
  - Electromagnetic Environment (EME)
- **Ranges**
  - National Cyber Range (NCR)
  - Joint IO Range (JIOR)
- **Maturing Capabilities**
  - Contested Cyber Environment (CCE)
  - Network Integration Environment (NIE)

DoD Cyber Transition to Practice (CTP) Initiative

Emerging "Best of Breed" S&T Matured through Cyber Range-based T&E, Demonstrations, and Operational Pilots



- **CTP is maturing and transitioning DoD-funded cyber S&T**
  - Get S&T addressing key gaps into Ops
  - White House priority
  - Increase TRL, reduce risk
- **CTP emphasizes:**
  - Rapid results near term
  - Committed transition partner(s)
  - Co-funding by transition partner(s)
- **FY14 funding: $4.2M**
- **Two white paper rounds so far**
  - Phase 1: DoD Labs, DARPA, NSA
  - Phase 2: UARCs, FFRDCs, SPAWAR
- **8 projects underway**
- **Future**
  - Planning currently underway for next phase of CTP

Industry Engagement - Way Ahead

- **Strategic DoD-Industrial cooperation in security marketplace**
  - Metrics development
  - Standards bodies participation/voting
  - Army: Cooperative development model with industry
  - Intellectual Property business cases that reduce market friction
- **DoD-Industrial Collaboration and Co-Development**
  - Personnel Exchanges
  - Cooperative R&D Agreements (CRADA)
  - Experimentation, T&E Ranges
- **Increase speed of cyber acquisition**
  - Enhanced M&S for early assessment of S&T candidates
  - Rapid-response S&T development
    - Examples: DARPA Cyber Fast Track, AFRL ACT IDIQ…other Services also exploring similar vehicles
- **OTHER IDEAS?**

Defense Innovation Marketplace

Resources For Industry And DoD

Improve Industry understanding of DoD needs

Marketplace: Resources for DoD

- Secure portal with 10,000+ IR&D Project Summaries
- Access for DoD S&T/ R&D and Acquisition Professionals
- DoD Searchers encouraged to contact the Industry POC listed on project summaries of interest

Marketplace: Resources for Industry

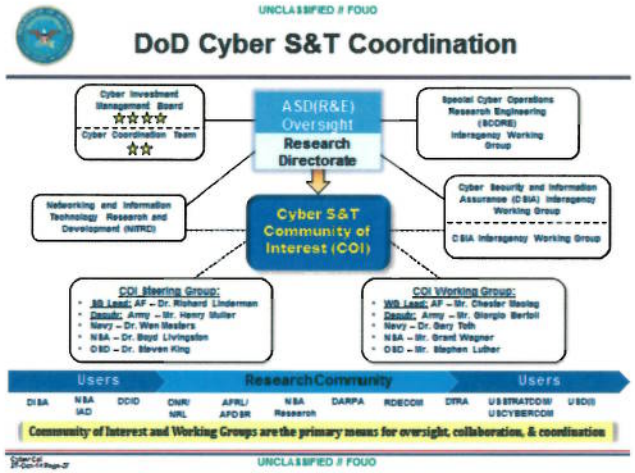
- DoD R&D Roadmaps; Investment Strategy
- Business Opportunities with the DoD
- Virtual Interchanges & Events
- Secure Portal for IR&D Project Summaries
- Top Downloads/Pages visited
- DoD IR&D SEARCH Trends

www.DefenseInnovationMarketplace.mil

Additional Resources

- **DIA Needipedia (http://www.dia.mil/Business/Needipedia.aspx)**
  - Provides a direct channel of Defense Intelligence Agency (DIA) needs into the emerging technology community
- **FedBizOps (https://www.fbo.gov/)**
  - Portal into government acquisitions providing a centralized repository for federal contract opportunities.
- **SBIR Announcements (http://www.dodsbir.net)**
  - Resource center for DoD SBIR
- **For more information on DoD cyber Science & Technology news, research needs and engagement opportunities, visit:**
  - Army Research Office (ARO)/Army Research Lab (ARL) (http://www.arl.army.mil)
  - Office of Naval Research (ONR) (http://www.onr.navy.mil)
  - Naval Research Laboratory (NRL) (http://www.nrl.navy.mil)
  - Air Force Office of Scientific Research (AFOSR) (http://www.afosr.af.mil)
  - Defense Advanced Research Projects Agency (DARPA) (http://www.darpa.mil)

Contacts



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Summary

- Established, mature, and coordinated community
- Cyber S&T aligned to expanding operational capability gaps/priorities
- Cyber S&T contributions to nearly all Seven DoD Hard Problems
- Driving deeper engagement with industry and international partners

BACKUP

DoD Cyber Ecosystem